The Practice of Application-Oriented Personnel Training in the Course of Information Theory and Coding

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Abstract. The course of Information Theory and Coding is abstract and highly theoretical. To improve the teaching quality and meet the society demand for technical and applicable talented persons, this paper proposes a specific way to optimizing the class teaching content and designing experiments to connect theory teaching and application practice. The course teaching focuses on theories of discrete information sources and channels and their applications in modern communication system. For experiments, the entropy of an English article is calculated. Then the article is compressed using the Shannon coding and Huffman coding. An experiment on forward error correction coding is proposed, which combines coding theories with digital television broadcasting application. The two years’ teaching practice shows that teaching effectiveness is improved by the teaching content optimization, and student’s learning interest increases significantly through experiments. The curriculum can adapt to the requirements of application-oriented education.

1. Introduction

Information theory, which is an important part of modern information science, has a deep and extensive influence on both the scientific research and the engineering practice for the design of communication systems and the information processing. Therefore, the undergraduate students majoring in electronic information should have a basic knowledge of information theory.

Information Theory and Coding is a specialized course for the major of electronic information engineering in many application-oriented universities [1-3]. However, it is an abstract and highly theoretical course. The theory is too difficult to be understood, resulting in students’ non-active and no goal studying [4]. Worse more, a lot of complicated calculation and mathematical derivations are contained; so many students only focus on how to calculate those mathematical equations with no understanding of their physical implications during the course, let alone how to apply the information theory and the coding methods in practice. Ultimately the teaching is ineffective.

To meet the demand of society for technical and applicable talented persons, application-oriented universities and colleges have the task of application-oriented personnel training [5-8]. The graduates should have distinctive features in their knowledge-capability-quality structure [9], which are steady theoretical basis, wide specialty knowledge, strong practical ability, and high comprehensive quality. The main purpose of application-oriented teaching mode is application and practice, with the core of the cultivation of ability. Therefore, it is necessary to change the traditional theory teaching mode and add application-oriented personnel training into in the highly theoretical course, like Information Theory and Coding.

This paper proposes a specific way to optimizing the teaching content, and also presents how to design experiments to connect the theory teaching and the practice, based on the course teaching reform practice in Tianjin University of Technology and Education (TUTE). In TUTE, Information Theory and Coding is an examination lecture for the juniors in the major of electronic information engineering.
2. Optimization of class teaching content

2.1 The reason for the content optimization

In the teaching process of Information and Coding, the common problem is that the wide coverage of contents and the limited time for the course severely affect the teaching and learning. It is necessary to appropriately choose the class teaching content according to the goal of application talent cultivation.

Theories about discrete information source and channel have been widely used in the practice of digital communication system design [10]. In the processing of continuous information source and channel, the continuous quantities were approximated as discrete ones with small intervals. Therefore, theories about discrete system are the basic of analyzing the continuous one. In the application, discrete digital communication system is becoming the most basic way of modern communication. Furthermore, the theories of the continuous information source and channel are more complex [11-13]. On the one hand, they are too difficult for students to learn. On the other hand, it spends more class time to teach those continuous theories. Due to the limited class hours, there is not enough time left to give a further in-depth and thorough analysis on theories of the discrete information source and channel. Accordingly, the class teaching content of Information Theory and Coding, which is the theory basis of the communication system design, should be adjusted based on the need of application [14] and the development of modern communication.

2.2 The optimization practice

In the reform practice of the course of Information Theory and Coding, we put emphasis on the optimization of class teaching content. More specifically, the course teaching focuses on the theories of discrete information sources and channels, which are widely used in modern communication system. The content about the continuous system is only introduced briefly, so that about 4 class hours are saved for a further in-depth explanation of the discrete information source and channel.

In the section of information source coding, the teaching key points are changed into the physical meaning of source coding theorems and their applications on the data compression, while the complicated theoretical demonstrations are taken away. Since the limited distorted coding theorems have been explained and applied in the Digital Image Processing course, only the undistorted source coding theorems are focused on in the Information Theory and Coding course.

The section of channel coding includes two parts that are the channel coding theory and the coding methods. The focus here is on the latter, while the former can be arranged as the content for self-study. In addition, the knowledge about the block code and convolutional code is the key content in this section because it has been in wide use in engineering. For example, BCH coding is widely used in CD, DVD and HDD, and convolutional coding is used in digital TV system combined with BCH coding.

The section of encryption coding also focuses on the coding methods, especially on the basic algorithms such as DES and RSA encryption algorithms. What’s more, to stimulate students’ interests, it is necessary to explain the application of those encryption coding methods in our daily life.

3. Combining theory and practice by experiments

Information theory and coding has a wide and profound influence on the theoretical research and engineering practice of communication. At present, information theory has been applied to a wide range of fields, such as economics, physics, biology, psychology, and so on. In the process of teaching, the lecture should consciously combine theory and engineering practice. It not only helps students to expand knowledge and understand the role theory and technology in many fields, but also to stimulate students’ interests in learning.

Experimental teaching is very important for students to consolidate theoretical knowledge, and to cultivate their ability to analyze and solve problems. Information Theory and Coding is a course that closely integrates theory and practice. If the lecture puts all attentions to theory and ignores
experimental knowledge, the students could only obtain the abstract theoretical knowledge, but not recognize the practical value of the curriculum. Therefore, it is necessary to strengthen the practice teaching. The emphasis and difficulty in information theory is encoding and decoding theory. And the students majoring in electronic information engineering have strong computer programming ability. We propose to set up a set of computer programming experiments on source and channel encoding and decoding algorithms. Students are required to implement each algorithm by C programming language.

The experiments on source coding include Shannon coding and Huffman coding. Shannon coding is the very basic application of the source coding theory. Huffman coding is the most often used one in lossless compression. In the experiments, an English article is compressed using the Shannon coding and Huffman coding. By the experiments, the students can have a taste on significance of coding theory.

Experiments of channel coding can be combined with the broadcasting system. We propose an experiment on forward error correction (FEC) coding which is related to another course of “digital TV”. The FEC coding in digital TV system has two additional error correcting codes. With the error correction ability of FEC coding, the decoder can not only find the errors, but also can find the locations of the error symbols, and automatically correct them. Due to no storage and feedback needed, the error correcting decoder can run in real-time. As a widely used technology in broadcast system, an experiment FEC can stimulate students’ interests in coding theory.

4. Results

Since 2016, the course of Information Theory and Coding has been changed into a 32 class-hour course, including 6 class-hour experiments in TUTE. Before that, the course had no experiment class hours. The result of class teaching content optimization and the designed experiments are shown in Table 1 with some comments.

<table>
<thead>
<tr>
<th>Class teaching content</th>
<th>Class hour</th>
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| **Chapter 1. Introduction**                    | 1          | Key point: the application of the information theory in our daily life,  
|                                                |            | not only in the design of communication system, but also in the areas  
|                                                |            | of finance and accounting, artificial intelligence and so on.          |
| **Chapter 2. Theories of discrete information sources and channels** | 10         | Contact those theories with the communication system since students have learnt some basic definitions in prerequisite course of Communication Theory. To stimulate students’ interest in learning, take an example of the stock risk calculation. Then a graph of English article is given for the practice. Students should review information source theories carefully before the experiment. |
| **Experiment 1: The calculation of information source entropy.** | 2          | The English article in Experiment 1 is compressed by Shannon coding and Huffman coding. Focus on BCH coding and convolutional coding methods combined with examples, like DVD and digital TV system. Prerequisite course: Digital TV. |
| **Chapter 3. Undistorted source coding theorems and methods.** | 5          | Focus on the physical meaning of theorems and their applications on the data compression. |
| **Experiment 2: Information source coding.**   | 2          | The design principle of BCH encoder and decoder is given in class. Require students complete the design by themselves in group. References for students: [15], [16], [17]. Focus on DES and RSA encryption algorithms. Take the secret communication in spy drama for example to introduce encryption algorithms. References for students: [18], [19], [20]. |
| **Chapter 4. Channel coding**                  | 7          |                                                                           |
| **Experiment 3: FEC coding in digital television system** | 2          |                                                                           |
| **Chapter 5. Encryption coding**               | 3          |                                                                           |
In the teaching practice, the limited experiment course hours are mainly used for the teacher’s explanation on experiment tasks, principles, requirements and design attentions. Students are divided into groups of three to complete tasks of experiments, which are taken as group assignments after class. To complete tasks, they need to review the basic theory knowledge learned in class, and also need to read some reference materials.

This teaching mode has attained preferable teaching results after two years’ practice. Students have great interest in the experiments with closeness to practice. Also, in turn, they get the motivation for learning basic theories in the practice, and do better in their final exam than those students taken no experiments.

5. Conclusion

By optimizing the teaching content, on one hand, the curriculum can be better adapted to the requirements of application-oriented education and to meet the needs of the current technological development; on the other hand, the lecture will have more time to explain the key knowledge intensively to improve the teaching effectiveness. Through the experiments, the teaching content and practice is combined to expand the students’ knowledge and understanding of the important role and significance of the information theory in many fields. Also, it can stimulate students’ interests in learning information theory.

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7. References


